CLAIMS

1. An actuator comprising:

a casing;

a stationary member which has a coil member and is mounted in the casing; and

a movable member which includes a moving element and is supported by the casing;

wherein the moving element has a shaft and is supported by the casing so as to be moved in an axial direction of the shaft and in a rotational direction having the axial direction of the shaft as its rotational axis;

wherein electric current is caused to flow through the coil member such that the moving element is moved in the axial direction and in the rotational direction;

wherein the stationary member includes a first stationary member for imparting to the movable member a force oriented in the axial direction and a second stationary member for imparting to the movable member a force oriented in the rotational direction;

wherein the coil member includes a first coil member for exciting a first magnetic path passing through the first stationary member and a second coil member for exciting a second magnetic path passing through the second stationary member.

2. The actuator as claimed in Claim 1, wherein the

first stationary member imparts to the moving element the force oriented in the axial direction and the second stationary member imparts to the moving element the force oriented in the rotational direction;

wherein the moving element includes a magnet member having a magnetization direction substantially orthogonal to the axial direction.

3. The actuator as claimed in Claim 2, wherein the magnet member of the moving element is disposed symmetrically with respect to the rotational axis.

4. The actuator as claimed in Claim 2, wherein the first stationary member includes a pair of first stationary elements provided symmetrically with respect to the rotational axis and the second stationary member includes a pair of second stationary elements provided symmetrically with respect to the rotational axis;

wherein the first coil member includes a pair of first coils each provided in each of the first stationary elements and the second coil member includes a pair of second coils each provided in each of the second stationary elements;

wherein the first coils excite the first stationary elements in an antiphase manner, respectively and the second coils excite the second stationary elements in an antiphase manner, respectively.

5. The actuator as claimed in Claim 4, wherein the first stationary elements and the second stationary elements are disposed such that an axial plane containing the first stationary elements and an axial plane containing the second stationary elements intersect with each other substantially orthogonally.

6. The actuator as claimed in Claim 4, wherein the magnet member of the moving element includes two magnets having opposite magnetization directions, respectively and each of the first stationary elements is formed by a substantially E-shaped magnetic part having three magnetic pole portions arranged in the axial direction.

7. The actuator as claimed in Claim 6, wherein each of the second stationary elements is formed by a substantially C-shaped magnetic part having two magnetic pole portions arranged in the axial direction.

8. The actuator as claimed in Claim 7, wherein opposite end portions of each of the first stationary elements and opposite end portions of each of the second stationary elements overlap each other in three dimensions when viewed in the axial direction.

9. The actuator as claimed in Claim 8, wherein a gap is formed between each of the magnetic pole portions of each of the first stationary elements and each of the magnetic pole portions of each of the second stationary

elements.

10. The actuator as claimed in Claim 7, wherein an end portion of each of the magnets of the moving element is rotated so as to traverse each of two recesses among the magnetic pole portions of each of the first stationary elements.

11. The actuator as claimed in Claim 7, wherein the magnets of the moving element are formed into an identical size;

wherein the magnets are provided such that not only opposed end faces of the magnets are brought into contact with each other in the axial direction but the other end faces of the magnets opposite to the contacting opposed end faces are flush with axial opposite end faces of each of the first stationary elements, respectively.

12. The actuator as claimed in Claim 1, further comprising:

an axial resonant spring for effecting resonant motion of the moving element in the axial direction, which is provided between the moving element and the casing.

13. The actuator as claimed in Claim 1, further comprising:

a rotational resonant spring for effecting resonant motion of the moving element in the rotational direction, which is provided between the moving element

and the casing.

14. The actuator as claimed in Claim 1, wherein the movable member further includes a further moving element disposed coaxially with the moving element and movable in the axial direction, the actuator further comprising:

a spring member which includes a first spring provided between the casing and the moving element, a second spring provided between the moving element and the further moving element and a third spring provided between the further moving element and the casing such that the first, second and third springs are deflectable in the axial direction.

15. The actuator as claimed in Claim 14, wherein the first stationary member and the second stationary member impart to one of the moving element and the further moving element the force oriented in the axial direction and the force oriented in the rotational direction, respectively.

16. The actuator as claimed in Claim 14, wherein the first stationary member imparts to one of the moving element and the further moving element the force oriented in the axial direction and the second stationary member imparts to the other of the moving element and the further moving element the force oriented in the rotational direction.

17. The actuator as claimed in Claim 15, wherein the

one of the moving element and the further moving element includes a magnet member disposed symmetrically with respect to the rotational axis and having a magnetization direction substantially orthogonal to the axial direction;

wherein the first stationary member includes a pair of first stationary elements provided symmetrically with respect to the rotational axis and the second stationary member includes a pair of second stationary elements provided symmetrically with respect to the rotational axis;

wherein the first coil member includes a pair of first coils each provided in each of the first stationary elements and the second coil member includes a pair of second coils each provided in each of the second stationary elements;

wherein the first coils excite the first stationary elements in an antiphase manner, respectively and the second coils excite the second stationary elements in an antiphase manner, respectively.

18. The actuator as claimed in Claim 16, wherein each of the moving element and the further moving element includes a magnet member disposed symmetrically with respect to the rotational axis and having a magnetization direction substantially orthogonal to the axial direction;

wherein the first stationary member includes a pair of first stationary elements provided symmetrically with

respect to the rotational axis and the second stationary member includes a pair of second stationary elements provided symmetrically with respect to the rotational axis;

wherein the first coil member includes a pair of first coils each provided in each of the first stationary elements and the second coil member includes a pair of second coils each provided in each of the second stationary elements;

wherein the first coils excite the first stationary elements in an antiphase manner, respectively and the second coils excite the second stationary elements in an antiphase manner, respectively.

19. The actuator as claimed in Claim 17, wherein the magnet member of the one of the moving element and the further moving element includes two magnets having opposite magnetization directions, respectively, with the one of the moving element and the further moving element undergoing from the first stationary member the force oriented in the axial direction;

wherein each of the first stationary elements is formed by a substantially E-shaped magnetic part having three magnetic pole portions arranged in the axial direction.

20. The actuator as claimed in Claim 18, wherein the magnet member of the one of the moving element and the further moving element includes two magnets having

opposite magnetization directions, respectively, with the one of the moving element and the further moving element undergoing from the first stationary member the force oriented in the axial direction;

wherein each of the first stationary elements is formed by a substantially E-shaped magnetic part having three magnetic pole portions arranged in the axial direction.

21. The actuator as claimed in Claim 19, wherein the magnet member of the one of the moving element and the further moving element includes two magnets having opposite magnetization directions, respectively, with the one of the moving element and the further moving element undergoing from the second stationary member the force oriented in the rotational direction;

wherein each of the second stationary elements is formed by a substantially C-shaped magnetic part having two magnetic pole portions arranged in the axial direction.

22. The actuator as claimed in Claim 20, wherein the magnet member of the other of the moving element and the further moving element includes two magnets having opposite magnetization directions, respectively, with the other of the moving element and the further moving element undergoing from the second stationary member the force oriented in the rotational direction;

wherein each of the second stationary elements

is formed by a substantially C-shaped magnetic part having two magnetic pole portions arranged in the axial direction.

23. The actuator as claimed in Claim 19, wherein an end portion of each of the magnets is rotated so as to traverse each of two recesses among the magnetic pole portions of each of the first stationary elements.